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DISCUSSION

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PREDICTING SEDIMENT YIELD IN WESTERN UNITED STATES[a]

Discussion by Kenneth G. Renard,[2] M. ASCE and J. Roger Simanton[3]

The author is to be commended for his analysis of a truly perplexing problem for a broad physiographic area containing almost every conceivable type of heterogeneity.

The hydrologic and sediment records of three livestock watering ponds on the Walnut Gulch Experimental Watershed in southeastern Arizona are used to supplement the material prepared by the author. Parameters X_1 (precipitation-temperature ratio), X_2 (land slope, as a percentage), X_3 (soil particles, as a percentage > 1 mm), and X_4 (soil aggregation) were determined using the method described by the author. A summary of these data is presented in Table 3.

The agreement of the method with actual data is encouraging except for the first pond listed in Table 3. In this instance, the prediction produced a negative sediment yield but the data indicated a positive sediment yield. The low watershed slope (producing a plus term) and the high percentage of gravel (producing a negative term) undoubtedly led to the negative prediction. The method is thus very sensitive at low sediment yields.

The writers feel that the X_1 parameter modification as an index of vegetative cover response for a particular climate might warrant additional investigation. It seems that more specific guidelines of rangeland vegetation cover are needed. A correction applied to plant density departures from some mean value for a specified precipitation-temperature ratio might be one approach.

In an effort to illustrate the sensitivity of the terms of the author's prediction equation, mean values for each parameter shown in Table 1 were determined. These mean values were then used for three terms while the remaining parameter was varied through the range of values shown in Table 1. Results of this work are shown in Fig. 2. Parameters X_1, X_2, and X_4 show the same magnitude of change in sediment yield for the range of values found in the table (i.e., the ends of each line represent the range of the parameter). The X_3 parameter shows very little effect on the sediment yield. The negative values shown in this figure are produced by using the average value for the parameters not being varied.

Renard (6) showed that, in most ephemeral streams, transmission losses have a marked effect on average sediment yield. Because water is the primary transporting agent, it is logical that transmission losses, which result in a decreasing watershed runoff with increasing area, would lead to a similar relationship for sediment yield. This work incorporated a stochastic runoff generating scheme with a deterministic sediment transport procedure involving Manning's equation

[a]December, 1972, by Elliot M. Flaxman (Proc. Paper 9432).

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and the Laursen transport relation. The model was tested against data for the outlet of Walnut Gulch as well as from the upper 36.7 sq miles (95.1 km^2) and then used to simulate results, storm by storm, for various sized tributaries.

TABLE 3.—Hydrologic and Sediment Records of Stock Pond Watersheds Near Tombstone, Ariz.

Watershed number (1)	Area, in square miles (square kilometers) (2)	Precipitation, in inches (centimeters) (3)	X_1 (4)	X_2 (5)	X_3 (6)	X_4 (7)	Sediment Yield, in acre-feet per square mile per year[a] Actual (8)	Predicted (9)
201	0.17 (0.44)	12.42 (31.6)	0.192	5.3	72	0	0.33	−0.18
214	0.58 (1.50)	11.30 (28.7)	0.179	8.6	52	0	0.31	0.24
223	0.17 (0.44)	11.02 (28.0)	0.172	9.4	65	0	0.38	0.16

[a] 1 acre-ft/mile^2 × 4.76 × 10^{-4} = 1 m^3/m^2.

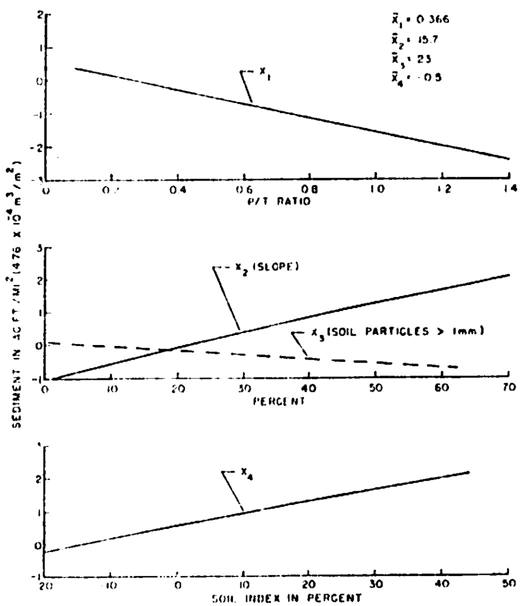

FIG. 2.—Parameter Sensitivity Analysis Using Average Values for Three Parameters While Varying Fourth

The work produced Eq. 2:

$$SY = 1.18\,A^{0.119} \quad \text{. . . . .} \quad (2)$$

in which SY = sediment yield, in acre-feet per square mile per year (1 acre-ft/mile^2 × 4.76 × 10^{-4} = /m^3/m^2); and A = drainage area, in acres (1 acre × 0.4047 = 1 ha). Eq. 2 states that a 1-acre (0.40-ha) area produces about 1.2 acre-ft per sq mile per yr (5.71×10^{-4} m^3/m^2) whereas 100 acre (40.5 ha) and 10,000 acre (4,047 ha) watersheds would be expected to produce 0.68 acre-ft and 0.52 acre-ft per sq mile per yr (3.24×10^{-4} $m^3 m^2$ and 2.47×10^{-4} m^3/m^2), respectively.

In an analysis such as the author has performed, this trend is likely lost when other streams reflecting increasing water yield with increasing area are considered. For example, the data presented in the paper would undoubtedly not have a correlation of sediment yield with drainage area because transmission losses would not be expected to dominant over the entire area considered.

A final point to be made regarding the paper involves the distribution of values for parameter X_4 (soil aggregation). Multiple regression techniques are valid when the dependent variables are expressible as a linear function of some known dependent variables with residual errors which are normally and independently distributed around zero with constant variance. The data the author presented in Table 1 do not resemble a normal distribution for parameter X_4, especially with the sharp peak at zero and minor peaks around -15 and $+15$. Even the logarithmic transformation with the constant added does not completely overcome the problem. Such a problem is not readily solved and is often a limiting criterion in multiple regression methods.

Appendix.—Reference

6. Renard, K. G., "Sediment Problems in the Arid and Semiarid Southwest," *Proceedings* of the 27th Annual Meeting of SCSA, Aug., 1972, pp. 225-232.

CAPITAL-COST MINIMIZATION OF HYDRAULIC NETWORK[a]

Errata

The following corrections should be made to the original paper:

Page 431, title: Should read "Networks" instead of "Network"
Page 434, Eq. 9: Should read $C_c = c\, l\, d^w$ instead of $C_c = c\, l\, d^{1/w}$
Page 434, line 5: Should read ". . . and w = a scaling factor typically in the range $1 \leq w \leq 1.5$" instead of ". . . and $1/w$ = a scaling factor typically in the range $1 \leq 1/w \leq 1.5$"
Page 434, paragraph 3, line 3: Should read $\gamma = cl(0.0252\ rl)^{w/5}$ instead of $\gamma = cl(0.0252\ rl)^w$

[a]March, 1973, by Ralf G. Cembrowicz and Joseph J. Harrington (Proc. Paper 9609).